U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-267 244

Freshwater Findings 1967-1976

Environmental Research Lab -Duluth, Minn

Mar 77

TECHNICAL REPORT DATA
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1. REPORT NO. EPA-600/9-77-005	2.
3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE: FRESHWATER FINDINGS 1967-1976. Research Publications of the Environmental Research Laboratory, Duluth, Minnesota	5. REPORT DATE: March 1977
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): Nichole J. Vick	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Environmental Research Laboratory-Duluth Office of Research and Development U.S. Environmental Protection Agency Duluth MN 55804	10. PROGRAM ELEMENT NO. 1BA608 11. CONTRACT/GRANT NO. --
12. SPONSORING AGENCY NAME AND ADDRESS: Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Duluth, Minnesota 55804	13. TYPE OF REPORT AND PERIOD COVERED: Bibliography 14. SPONSORING AGENCY CODE: EPA/600/03
15. SUPPLEMENTARY NOTES	

16. ABSTRACT

This bibliography, inclusive from 1967 through 1976, lists all publications authored by personnel of the Environmental Research Laboratory-Duluth (formerly the National Water Quality Laboratory). Not only does the bibliography list all scientific materials (journal articles, research reports, and other) published by the laboratory staff, but also those project reports prepared by universities, industries, and other government researchers conducting studies under the funding and direction of this laboratory.

The publications are grouped in three sections---reports published by the EPA's (and precursor agencies') research series, journal articles from the scientific literature, and other scientific publications. Each category is subdivided into 1976 publications (annotated) and those published from 1967 through 1975. Within each year, publications are listed alphabetically by the senior author's last name, and sources of reprints are identified. Introductory materials include a list of standard abbreviations for scientific journals cited and pertinent components of the EPA and the laboratory. The bibliography concludes with an author index for all entries and a key word index for the 1976 publications. All entries are numbered consecutively throughout the three sections of the bibliography, and those numbers are used in the indices.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Research projects Technical reports Abstracting Fresh water biology	Publications summary Bibliography Environmental Research Laboratory-Duluth	05B 06A,C,F,S,T

18. DISTRIBUTION STATEMENT: RELEASE TO PUBLIC	19. SECURITY CLASS (This Report): UNCLASSIFIED	21. NO. OF PAGES: 77
	20. SECURITY CLASS (This page): UNCLASSIFIED	22. PRICE: A05-A01

EPA Form 2220-1 (9-73)

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EPA-600/9-77-005
March 1977

FRESHWATER FINDINGS, 1967-1976

Research Publications of the
Environmental Research Laboratory
Duluth, Minnesota

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PB 267 244

U.S. Environmental Protection Agency

Office of Research and Development

EPA-600/9-77-005

FRESHWATER FINDINGS 1967-1976

research publications of the environmental research laboratory duluth, minnesota

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1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies

This report has been assigned to the ECOLOGICAL RESEARCH series. This series describes research on the effects of pollution on humans, plant and animal species, and materials. Problems are assessed for their long- and short-term influences. Investigations include formation, transport, and pathway studies to determine the fate of pollutants and their effects. This work provides the technical basis for setting standards to minimize undesirable changes in living organisms in the aquatic, terrestrial, and atmospheric environments.

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FOREWORD

Our nation's freshwaters are vital for all animals and plants, yet our diverse uses of water---for recreation, food, energy, transportation, and industry---physically and chemically alter lakes, rivers, and streams. Such alterations threaten terrestrial organisms, as well as those living in water. The Environmental Research Laboratory in Duluth, Minnesota develops methods, conducts laboratory and field studies, and extrapolates research findings

--to determine how physical and chemical pollution affects aquatic life

--to assess the effects of ecosystems on pollutants

--to predict effects of pollutants on large lakes through use of models

--to measure bioaccumulation of pollutants in aquatic organisms that are consumed by other animals, including man

Recognizing that the research findings of the Environmental Research Laboratory-Duluth comprise a significant contribution to freshwater data, this volume provides a complete compilation of the scientific publications documenting those findings. This bibliography, inclusive from 1967 through 1976, lists all project reports prepared by universities, industries, and other government researchers conducting studies under the funding and direction of the Environmental Research Laboratory-Duluth. Furthermore, this list includes all scientific materials---journal articles, research reports, and other publications---authored by the laboratory's own staff.

We offer this compilation with the belief that our findings are useful only if we avail them to the broadest possible audience to ensure that other researchers, regulatory agencies, and the public can apply this knowledge to help us protect our nation's freshwaters.

Donald I. Mount, Ph.D.
Director
Environmental Research Laboratory
Duluth, Minnesota

PREFACE

Dedicated in 1967 as the National Water Quality Laboratory, the name of the facility stated its purpose---to develop and apply test methods to evaluate how pollution affects the plants and animals living in lakes, rivers, and streams.

Early efforts pioneered frewhwater research on how pollutants directly affect aquatic life itself. However, the laboratory has increasingly innovated critical research on how humans and wildlife, as well as aquatic life, are affected by freshwater organisms contaminated with pollutants.

By 1975 that expanding mission called for a new name---the Environmental Research Laboratory-Duluth (ERL-D). As one of fifteen unique laboratories of the U.S. Environmental Protection Agency's Office of Research and Development, the laboratory continues its wide range of aquatic research having both national and international impact.

Since 1967, staff scientists in Duluth and at ERL-D's field stations have made their research results available to other scientists. By publishing in the technical literature, government reports, and other scientific materials, ERL-D researchers have shared their expertise.

Other researchers in industry, universities, and other government agencies throughout the country have received funding from ERL-D to conduct freshwater studies that complement the work of the ERL-D staff. To ensure that a complete record of that work is available to the public, the Environmental Protection Agency stipulates that each project must yield a comprehensive final report that the Agency publishes in its research report series. Projects completed by ERL-D staff also are reported in that series.

All of these findings by ERL-D staff and the extramural scientists funded by the laboratory comprise a significant portion of the data that regulatory agencies use to set criteria that protect fresh water life---criteria that ultimately protect humans and other animals that drink or consume food from those waters.

To ensure that this information is readily available to others who can apply these findings to maintain and improve fresh water quality, this bibliography provides a complete---through 1976---listing of those research publications and sources of reprints.

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The publications are grouped in three main sections---reports published in the Environmental Protection Agency's (and precursor agencies') research series, journal articles from the scientific literature, and other scientific publications. Each of those categories is subdivided into 1976 publications (annotated to give the reader more complete information) and those published from 1967 (the year the laboratory was dedicated) through 1975. Within each year, publications are listed alphabetically by the senior author's last name. To help the reader get copies of available publications, the citations for available publications also identify sources of reprints.

To make the bibliography more usable to readers, it includes an author index for all entries and a key word index for the 1976 publications. All entries are numbered consecutively throughout the three sections of the bibliography, and those are the numbers used in the indices.

Introductory materials also include a list of standard abbreviations for the scientific journals cited in the bibliography and for pertinent components of the Environmental Protection Agency and this laboratory.

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ACKNOWLEDGMENTS

Special thanks are given to Melanie Higdon for typing this bibliography and for helping with its compilation and final preparation. Without Melanie's help, this bibliography would still be an idea. Barbara Halligan also deserves credit for the cover art.

LIST OF ABBREVIATIONS
Journals

Adv. X-Ray Anal.	Advances in X-Ray Analysis
Am. Midl. Nat.	The American Midland Naturalist
Anal. Chem.	Analytical Chemistry
Bull. Environ. Contam. Toxicol.	Bulletin of Environmental Contamination and Toxicology
Can. Entomol.	Canadian Entomologist
Chem.-Biol. Interactions	Chemico-Biological Interactions
Chem. Instrum.	Chemical Instrumentation
Environ. Health Perspect.	Environmental Health Perspective
Environ. Sci. Technol.	Environmental Science and Technology
J. Am. Water Works Assoc.	Journal of the American Water Works Association
J. Assoc. Off. Anal. Chem.	Journal of the Association of Official Analytical Chemists
J. Chromatogr.	Journal of Chromatography
J. Fish. Res. Board Can.	Journal of the Fisheries Research Board of Canada
J. Insect Physiol.	Journal of Insect Physiology
J. Kans. Entomol. Soc.	Journal of the Kansas Entomological Society
J. Minn. Acad. Sci.	Journal of the Minnesota Academy of Science
J. N. Engl. Water Works Assoc.	Journal of the New England Water Works Association
J. Water Pollut. Control Fed.	Journal of the Water Pollution Control Federation
J. Wildl. Manage.	Journal of Wildlife Management
Malacologia	Malacologia (International Journal of Malacology)
Mar. Technol. Soc. J.	Marine Technology Society Journal
Mich. Entomol.	Michigan Entomologist
Nautilus	Nautilus

Pestic. Monit. J.	Pesticides Monitoring Journal
Prog. Fish-Cult.	Progressive Fish-Culturist
Science	Science
Toxicol. Appl. Pharmacol.	Toxicology and Applied Pharmacology
Trans. Am. Fish. Soc.	Transactions of the American Fisheries Society
Verh. Internat. Verein. Limnol.	International Association of Theoretical and Applied Limnology, Verhandlungen
Water Res.	Water Research

other

EPA	U.S. Environmental Protection Agency Washington, D.C. 20460
ERL-D	Environmental Research Laboratory-Duluth 6201 Congdon Boulevard Duluth MN 55804
LLRS	Large Lakes Research Station* 9311 Groh Road Grosse Ile MI 48138
MERS	Monticello Ecological Research Station* P.O. Box 500 Monticello MN 55362
NFTS	Newtown Fish Toxicology Station* 3411 Church street Newtown OH 45244
NTIS	National Technical Information Service U.S. Department of Commerce Springfield VA 22161
ORD	Office of Research of Development U.S. Environmental Protection Agency Washington, D.C. 20460

*ERL-D Field Stations

RESEARCH REPORTS

Reports in this section, published by the Agency in its own report series, provide a complete public record of the research activities funded by the Environmental Research Laboratory-Duluth. Consequently, the authors of these reports include not only the laboratory staff members, but also those scientists at universities, in industry, and at other facilities who receive funding and perform research under the direction of the Environmental Research Laboratory-Duluth.

1976

1 Adelman, Ira R. and Lloyd L. Smith, Jr. 1976. STANDARD TEST FISH DEVELOPMENT, PART I. University of Minnesota, St. Paul MN. Publication No. EPA-600/3-76-061a. 87 p.

Fathead minnows and goldfish were compared for their suitability as a standard bioassay fish. Acute bioassays of four potential reference toxicants, sodium chloride, pentachlorophenol, hexavalent chromium, and Guthion® were conducted with both species, and results were reported as toxicity curves as well as LC50s at various times. Both species showed the same variability of bioassay results. Since goldfish could not complete a life cycle in one year under laboratory conditions, fathead minnows were recommended as a standard species on the basis of their smaller size and their utility in complete life cycle tests.

Bioassays of pentachlorophenol were conducted with both species to determine the effect of testing different sized fish of the same age or testing different aged fish. Size selection of fish within the ranges tested appeared unnecessary since differences in LC50s were small. Since age of fathead minnows did not affect the LC50s after 24 hours, use of younger fish would allow smaller bioassay chambers or more fish per chamber.

On the basis of seven criteria, sodium chloride was superior for use as a reference toxicant with pentachlorophenol a close second choice.

Source: ERL-D -or-

NTIS, No. PB258099/AS
Price: Paper copy $5.00, Microfiche $3.00

2 Adelman, Ira R. and Lloyd L. Smith, Jr. 1976. STANDARD TEST FISH DEVELOPMENT, PART II. University of Minnesota, St. Paul MN. Publication No. EPA-600/3-76-061b. 31 p.

Three chronic bioassays of Guthion® were conducted with fathead minnows. All tests began with eggs, and the longest lasted 20 days after termination of spawning, a total of 250 days. Parameters measured were survival, growth, fecundity, and growth and survival of second generation fry and eggs. The most sensitive criterion for effect of the toxicant was fecundity. The maximum acceptable toxicant concentration was between 0.33 and 0.51 ug/l Guthion® and the application factor between .00017 and .00027.

Source: ERL-D -or-

NTIS, No. PB257785/AS
Price: Paper copy $4.00, Microfiche $3.00

3 Basch, R.E. and J.G. Truchan. 1976. TOXICITY OF CHLORINATED POWER PLANT CONDENSER COOLING WATERS TO FISH. Michigan Water Resources Commission, Lansing, MI. Publication No. EPA-600/3-76-009. 115 p.

During 1972 studies at five Michigan power plants held caged brown trout (Salmo trutta) and fathead minnows (Pimephales promelas) for 96 hr in the intake and condenser cooling water discharge channels and in condenser cooling water dechlorinated with sodium thiosulfate. Below four of the five plants, total residual chlorine levels as low as 0.05 mg/l were lethal to brown trout. Total residual chlorine concentrations lethal to 50 percent (LC-50) of the caged brown trout at two plants averaged 0.02 to 0.18 mg/l during the chlorination periods. Fathead minnow deaths in all studies could not be attributed to the total residual chlorine.

Resident fish were observed in distress at two plants during 1972. These behavioral symptoms were noted at maximum total residual chlorine concentrations ranging from 0.2 to 0.5 mg/l.

Studies were repeated in 1973 at one plant with brown trout and other salmonid species. No deaths of test fish during these tests could be attributed to chlorine concentrations. The inconsistent results may be related to interactions between chlorine, temperature, and dissolved oxygen saturation in the discharge channel.

Source: ERL-D -or-

NTIS, No. PB253780/AS
Price: Paper copy $5.50, Microfiche $3.00

4 Reeton, A.M., P.K. Kovacic, and A.S. Brooks. 1976. EFFECTS OF CHLORINE AND SULFITE REDUCTION ON LAKE MICHIGAN INVERTEBRATES. University of Wisconsin, Milwaukee. Publication No. EPA-600/3-76-036. 132 p.

The acute toxicity of residual chlorine was determined for the copepod Cyclops bicuspidatus thomasi and the rotifer Keratella cochlearis. The 96-hour TL_{50} value for Cyclops was 0.084 mg/l total residual chlorine added as monochloramine. When Cyclops was exposed to sodium hypochlorite, the 96-hour TL_{50} was 0.069 mg/l total residual chlorine. The 4-hour TL_{50} value for Keratella was 0.019 mg/l total residual chlorine added as monochloramine.

Chemical studies determined that sodium sulfite was an efficient, inexpensive chemical agent for reducing chlorine residuals which did not produce undesirable by-products. Complete reduction was accomplished in less than 20 seconds with a calculated K_{min} of 43 sec^{-1}. Bioassay studies indicated that sodium sulfite added to chlorinated water completely eliminated the acute toxicity of residual chlorine to both Cyclops bicuspidatus thomasi and Keratella cochlearis.

Field studies in Milwaukee Harbor and adjacent Lake Michigan indicated that measurable chlorine residuals were confined to a very small area surrounding the effluent from the Jones Island Sewage Treatment Plant. Significant reductions in the populations of benthic organisms were observed in the effluent plume area after the start of chlorination.

Source: ERL-D -or-

NTIS, No. PB253127/AS
Price: Paper copy $6.00, Microfiche $3.00

5 Rouck, Gerald R., Allen V. Nebeker, and Donald G. Stevens. 1976. MORTALITY, SALTWATER ADAPTATION AND REPRODUCTION OF FISH DURING GAS SUPERSATURATION. Western Fish Toxicology Station, Corvallis OR (formerly a field station of the Environmental Research Laboratory, Duluth MN). Publication No. EPA-600/3-76-050. 55 p.

Tests were conducted using continuous exposure in shallow water at levels of total dissolved gas pressure ranging from 110-140% of barometric pressure (hyperbaric pressure = 103-410 g/cm^2). Times to 20% and to median mortality were determined on several life stages of Pacific salmonids (Oncorhynchus and Salmo) and largemouth bass (Micropterus salmoides). Mean times to 20% mortality at 115% total gas saturation were 309, 154 and 125 hours for adults, smolts, and parr, respectively. At 120% saturation mean times to 20% mortality were 48, 41 and 53 hours for adults, smolts, and parr, respectively. At 125% saturation mean times to 20% mortality decreased to 18, 17, and 24 hours respectively for adults, smolts, and parr. Factors

influencing time to death included genera, life stage, acclimation temperature, activity level, sex, and body size. Mortality curves typically were skewed to the right. Gross pathology of gas bubble disease was described relative to these experiments. High gas levels that killed 50% of three species of salmon smolts had no apparent effect on the ability of the survivors to tolerate an immediate transfer into seawater (30 ppt Cl). Long-term (three-month) continuous exposure of adult spring chinook salmon to 110% saturation had no readily apparent adverse impact on the fertilization and hatching of their eggs.

Source: ERL-D -or-

NTIS, No. PB253777/AS
Price: Paper copy $4.50, Microfiche $3.00

6 Broderius, Steven J. and Lloyd L. Smith, Jr. 1976. EFFECT OF HYDROGEN SULFIDE ON FISH AND INVERTEBRATES, PART II -- HYDROGEN SULFIDE DETERMINATION AND RELATIONSHIP BETWEEN pH AND SULFIDE TOXICITY. University of Minnesota, St. Paul MN. Publication No. EPA-600/3-76-062b. 119 p.

An analytical method was developed for the direct determination of µg/l concentrations of molecular H_2S. The procedure involves bubbling compressed nitrogen through an aqueous sulfide solution to displace H_2S which is collected in a glass bead concentration column and measured colorimetrically. The H_2S concentration is calculated from the determined sulfide displacement rate and by reference to a log linear standard curve relating temperature with the H_2S displacement rate to the H_2S concentration in standard solutions. To permit accurate determination of H_2S from the determined dissolved sulfide concentration and fraction of dissolved sulfide as H_2S for specific conditions of temperature and pH, the apparent linear relationship between pK_1 for $H_2S_{(aq)}$ and temperature was defined. This procedure of calculating H_2S in various waters and effluents was confirmed by the direct technique.

The described analytical technique was used to define the relationship between test pH and sulfide toxicity to the fathead minnow. Within the pH range of 7.1 to 8.7, 96-hr LC50 values for molecular H_2S decreased linearly from 57.3 to 14.9 µg/l with increasing pH. However, the log 96-hr LC50 values of dissolved sulfide increased linearly from 64.0 to 780.1 µg/l with increasing test pH ranging from 6.5 to 8.7.

Source: ERL-D -or-

NTIS, No. PB257246/AS
Price: Paper copy $5.50, Microfiche $3.00

7 Brungs, William A. 1976. EFFECTS OF WASTEWATER AND COOLING WATER CHLORINATION ON AQUATIC LIFE. Environmental Research Laboratory, Duluth MN. Publication No. EPA-600/3-76-098. 52 p.

The literature since 1972 pertaining to wastewater and cooling water chlorination is discussed under the headings: Review papers, chlorinated municipal wastewaters, continuously chlorinated water, intermittently chlorinated water, dechlorination, avoidance, formation of chlorinated organic compounds, aquatic life criteria and application factors, and regulations.

Field and laboratory research results support a single criterion of 0.003 mg/l for continuous exposure of freshwater organisms. The former distinction between warmwater and coldwater systems is no longer appropriate as recent data indicate that several freshwater fish species are as sensitive as trout or salmon.

The present concern about the formation of chlorinated organics in water and wastewaters is justifiable and the greatest present need is to determine the ecological significance, if any, of these results. The future course of wastewater chlorination will be greatly influenced by the recent proposed changes in the Environmental Protection Agency's regulations on secondary treatment. The changes intend that disinfection only be considered when public health hazards need to be controlled and that the exclusive use of chlorine should not be considered where protection of aquatic life is of primary consideration. Where these uses co-exist, alternate means of disinfection must be considered.

Source: ERL-D -or-

NTIS, No. PB257700/AS
Price: Paper copy $4.50, Microfiche $3.00

8 Cardwell, Rick D., Dallas G. Foreman, Thomas R. Payne, and Doris J. Wilbur. 1976. ACUTE TOXICITY OF SELECTED TOXICANTS TO SIX SPECIES OF FISH. Chemico Process Plants Company--Envirogenics Systems, El Monte, CA. Publication No. EPA-600/3-76-008. 125 p.

The relationship between median lethal concentration and exposure time was determined for five chemicals and up to six species of freshwater fish in a flow-through system. The lowest median lethal concentrations found were 0.0114 mg/l for sodium cyanide, 0.118 mg/l for sodium pentachlorophenate, 2.9 mg/l for selenium dioxide, 18.0 mg/l for sodium arsenite, 25.4 mg/l for beryllium sulfate, and greater than 100 mg/l for lead chloride.

. Toxicity curves relating median lethal concentration to exposure time were of three types. One curve, resembling a

rectangular hyperbola, characterized the toxicity of sodium cyanide, while a sigmoid-shaped curve characterized the toxicity of selenium dioxide. Both types of curves were observed in toxicity tests with sodium pentachlorophenate, sodium arsenite, and beryllium sulfate. Linear toxicity curves were recorded for some fish species exposed to selenium dioxide, sodium arsenite, and beryllium sulfate, but usually when exposure times were less than 96 hr.

Source: ERL-D -or-

NTIS, No. PB252488/AS
Price: Paper copy $5.50, Microfiche $3.00

9 Cowen, William F. and G. Fred Lee. 1976. ALGAL NUTRIENT AVAILABILITY AND LIMITATION IN LAKE ONTARIO DURING IFYGL. PART I - AVAILABLE PHOSPHORUS IN URBAN RUNOFF AND LAKE ONTARIO TRIBUTARY WATERS. University of Texas at Dallas, Richardson, Texas. Publication No. EPA-600/3-76-094a. 217 p.

Samples of Madison urban runoff, precipitation from Madison and New York State were analyzed for various forms of phosphorus to estimate the algal-available fraction of each of these P forms. Urban runoff particulate P forms from Madison runoff showed acid extractable inorganic P in the range of 33 to 46% of the particulate P. Ranges for the OH^- and for exchange resin extractable inorganic P were 22 to 27 and 13 to 17% of particulate P, respectively. Runoff from urban areas in the Genesee R. basin (N.Y.) showed acid, base, and resin extractable inorganic P in the ranges of 30 to 48, 18 to 30 and 11 to 25% of particulate P, respectively, in general agreement with the Madison samples. Inorganic P extracted from particulate P by resin in long-term aerobic dark incubations was similar to that extracted by the resin in short-term tests, indicating that physical and chemical, rather than microbial mineralization processes were probably the key factors regulating the release of inorganic P from the runoff particles to the solution phase.

Source: LLRS

10 Dawley, Earl, Bruce Monk, Michael Schiewe, Frank Ossiander, and W. Ebel. 1976. SALMONID BIOASSAY OF SUPERSATURATED DISSOLVED AIR IN WATER. National Marine Fisheries Service, Seattle WA. Publication No. EPA-600/3-76-056. 39 p.

Tests were conducted in shallow (0.25 m) and deep (2.5 m) tanks of water at 10C with concentrations of dissolved atmospheric gas ranging from 100% to 127% of air saturation to determine the lethal and sublethal effects on juvenile fall chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Salmo gairdneri).

Fall chinook salmon (average fork length of 42 mm) were much more resistant to supersaturation than juvenile steelhead trout (average fork length of 180 mm). Salmon tested in the shallow tanks at 120% of saturation incurred 50% mortality in 22 days whereas trout tested at the same level incurred 50% mortality in 30 hours. Signs of gas bubble disease were noted on dead fish and on subsamples of live fish from deep water tests at 110% saturation and in shallow water tests at 105% or above. Vertical distribution of both salmon and trout in the deep tanks appeared to compensate for about 10% and 10-15% respectively of effective saturation. Average depth of the fish in deep tanks increased with increased gas concentration. Significant differences in growth and condition factors of the salmon and trout were not found between stressed and control fish during the test period.

Source: ERL-D -or-

NTIS, No. PB256413/AS
Price: Paper copy $4.00, Microfiche $3.00

11 Duodoroff, Peter. 1976. TOXICITY TO FISH OF CYANIDES AND RELATED COMPOUNDS---A REVIEW. Oregon State University, Corvallis OR. Publication No. EPA-600/3-76-038. 161 p.

The world literature on the toxicity to fish of simple and complex cyanides is reviewed critically and interpretively. Differently determined limits of toxicant concentrations tolerated by various fishes are compared and their variation (with exposure time, pH, temperature, dissolved oxygen and mineral content of the water, body size, age, acclimation, and other factors) is examined. Interactions of free cyanide with other toxic water pollutants also are considered. Available data on effects of sublethal levels of free cyanide on growth, food consumption and utilization, swimming ability, behavior, etc., and observations on avoidance reactions of fish to the toxicant are summarized and their ecological significance is discussed. After a brief introduction to the chemistry of complex metallocyanides and their behavior in dilute solutions, the acute toxicity of the solutions is thoroughly considered and related to concentrations of their identifiable components. The dominant role of molecular hydrocyanic acid produced by dissociation of photolysis of the metallocyanide complexes as a lethal agent responsible for the toxicity of most of the toxic solutions tested is given particular attention; the relative toxicity of complex metallocyanide ions also is considered. Some conclusions regarding acceptable concentrations of free cyanide in receiving waters are presented.

Source: ERL-D -or-

NTIS, No. PB253528/AS
Price: Paper copy $6.75, Microfiche $3.00

12 Fryer, J.L., K.S. Pilcher, J.E. Sanders, J.S. Rohovec, J.L. Zinn, W.J. Groberg, and R.H. McCoy. 1976. TEMPERATURE, INFECTIOUS DISEASES AND THE IMMUNE RESPONSE IN SALMONID FISH. Oregon State University, Corvallis OR. Publication No. EPA-600/3-76-021. 80 p.

To investigate the effect of temperature on infections of salmonid fish, Aeromonas salmonicida infection was studied in chinook salmon and steel head trout and Aeromonas liquefaciens infection was studied in chinook and coho salmon. In all cases, mortality rates were high at 64 to 69 F; usually moderate at 54 to 59 F; and low or zero at 39 to 49 F. Progress of the infections accelerated at higher temperatures and retarded at lower temperatures. Bacterial kidney disease was studied in coho salmon and steelhead trout. Temperatures from 44 to 54 F were optimal for development of fatal infection, indicated by mortality rates of 78 to 100%. Higher temperatures had a suppressing effect marked at 69 F. Temperatures of 59 to 69 F were optimal for the formation of agglutinating antibody when juvenile coho salmon were injected with a killed suspension of A. salmonicida. At lower temperatures less antibody was formed, and no significant amount was produced at 39 F 60 days after injection of antigen. Oral immunization of juvenile coho salmon with a vaccine consisting of formalin killed Vibrio anguillarum cells incorporated in their diet protected them against fatal infection when the fish were held at temperatures from 39 to 69 F during immunization.

Source: ERL-D -or-

NTIS, No. PB253191/AS
Price: Paper copy $5.00, Microfiche $3.00

13 Geckler, Jack R., William B. Horning, Timothy M. Neiheisel, Quentin H. Pickering, Ernest L. Robinson, and Charles E. Stephan. 1976. VALIDITY OF LABORATORY TESTS FOR PREDICTING COPPER TOXICITY IN STREAMS. Newtown Fish Toxicology Station, Newtown OH. Publication No. EPA-600/3-76-116. 206 p.

A field study was conducted on Shayler Run, in Clermont County, Ohio, to determine the effects of copper on the stream biota. Copper was added to the stream for 33 months to maintain a concentration of 120 µg/l, a concentration that was expected to adversely affect some species of fish and not others. This natural stream received sewage effluent containing a variety of compounds known to affect acute copper toxicity. All but one abundant species of fish in the stream and four of the five most abundant macroinvertebrates were adversely affected by exposure to copper. Direct effects on fish were death, avoidance, and restricted spawning.

To determine the usefulness of laboratory toxicity tests when establishing water quality criteria for an aquatic ecosystem, acute and chronic tests with copper were conducted at the Newtown

Fish Toxicology Station and on-site at Shayler Run with stream species and the fathead minnow. The acute toxicity of copper varied widely because of water quality variations in the stream. The chronic tests underestimated the in-stream toxicity by about two times because only the effects of copper on survival, growth, and reproduction were measured. Agreement between the predictions from laboratory toxicity tests and the observed effect is surprisingly close considering the measurement errors involved.

Source: ERL-D -or- NTIS

14 Gerloff, Gerald C. and George P. Fitzgerald. 1976. THE NUTRITION OF GREAT LAKES CLADOPHORA. University of Wisocnsin, Madison. Publication No. EPA-600/3-76-004. 123 p.

A synthetic culture medium was developed for the laboratory culture of Cladophora glomerata from the Great Lakes. Recognition that Cladophora requires vitamins B_1 and B_{12} was a key feature in the successful culture of this alga. Systematic modifications of the initial culture solution resulted in an optimum culture medium in which C. glomerata routinely produced 500 mg oven-dry algae in a 21-day period.

The quantitative requirements of C. glomerata for essential inorganic nutrients were expressed primarily as critical cell concentrations, that is, minimum cell concentrations which permit maximum yield. C. glomerata has relatively low critical N and P concentrations (1.1% and 0.06%, respectively) but very high B (110 ppm) and S (0.15%) critical concentrations. Ortho-, pyro-, meta, and tripoly-P can be utilized in C. glomerata growth as can NH_4 and NO_3-N. Phosphite-P is relatively unavailable.

Nutrient supplies and limiting nutrients for Cladophora sp. growth in the Great Lakes were evaluated by two bioassays, primarily plant analysis and to some extent the Fitzgerald tests. Plant analysis assays for P showed that Cladophora P concentrations correlated closely with the recognized pollution of areas sampled. Furthermore, P was limiting or close to limiting in several relatively unpolluted areas. There were indications that elements other than P at times limited Cladophora growth.

Source: LLRS -or-

NTIS, No. PB253343/AS
Price: Paper copy $5.50, Microfiche $3.00

15 Great Lakes Laboratory, State University College. 1976. AN INVESTIGATION OF THE NEARSHORE REGION OF LAKE ONTARIO IFYGL. Great Lakes Laboratory, Buffalo, New York. Publication No. EPA-600/3-76-115. 269 p.

Sufficient quantitative and qualitative information concerning water and sediment chemistry, phytoplankton, zooplankton and benthos, in addition to a limited number of physical parameters between April 1972 and May 1973 was collected to establish an environmental baseline for the Welland Canal - Rochester nearshore zone. This information could be of value in evaluating future ecological changes in the aquatic region as well as in the construction of water intakes, beaches, power generating plants and other shoreline projects. The study area could generally be characterized as oligotrophic to mesotrophic. The lowest quality conditions were observed at the Genesee and Niagara River mouths. The thermal bar functioned as a barrier which kept the more nutrient enriched water on the shoreward side of the bar. Cladophora growth appeared to be limited by suitable substrate for attachment and the extent of wave action rather than chemical factors. The physical nature of the sediment also appeared to be of major importance in determining which benthos were found in which regions of the study area.

Source: LLRS -or- NTIS

16 Jarvinen, Alfred W., Molly J. Hoffman, and Todd W. Thorslund. 1976. TOXICITY OF DDT FOOD AND WATER EXPOSURE TO FATHEAD MINNOWS. Environmental Research Laboratory, Duluth MN. Publication No. EPA-600/3-76-114. 75 p.

Fathead minnows (Pimephales promelas) were exposed during a partial chronic toxicity test to two DDT concentrations in the water, one in the diet, and combinations of water and diet for 266 days through a reproductive period of their life cycle. Tissue-residue analyses were performed on test fish at preset intervals throughout the exposure and also on embryos, larvae at hatch, and 30- and 60-day progeny. The contribution of DDT from each source was monitored with gas-chromatography and liquid-scintillation techniques. The diet was clams that had accumulated 14C-DDT when exposed at a DDT water concentration similar to that in the high fish exposure.

Higher total DDT tissue residues were accumulated from the water than from the diet. Residues contributed by dietary DDT were additive to those from the water. Mean concentration factors were 1.2 times from the diet and 100,000 times from the water. Mortality was higher in fish exposed to DDT in both water and diet than in fish exposed to only one or the other of these sources. DDT in the diet significantly reduced the probability of survival of the test fish ($P = 0.025$). Estimated maximum acceptable toxicant concentrations for DDT are 0.9 µg/l for fish exposed to DDT in the water only or 0.4 µg/l for fish exposed to DDT in both water and diet.

Source: ERL-D -or- NTIS

17 Lick, Wilbert. 1976. NUMERICAL MODELS OF LAKE CURRENTS. Case Western Reserve University, Cleveland OH. Publication No. EPA-600/3-76-020. 152 p.

As part of a research effort sponsored by the U.S. Environmental Protection Agency to study the dispersion of contaminants in near-shore areas of large lakes, the author developed numerical models capable of realistically describing the currents throughout large lakes and, in particular, in the near-shore regions of these lakes. This report summarizes work to date on these hydrodynamic models.

This work has emphasized the development and use of three-dimensional models. This report describes three basic models: (1) a steady-state, constant-density model; (2) a time-dependent, constant-density model; and (3) a time-dependent, variable-density model. Each model has its own limitations and certain advantages over the others. Applications of each model, especially to flows in near-shore regions, are discussed. Because the author also has used vertically averaged models, usually in parametric studies, the report briefly summarizes these models.

Source: LLRS -or-

NTIS, No. PB252835/AS
Price: Paper copy $6.75, Microfiche $3.00

18 Macek, Kenneth J., Kenneth S. Buxton, Steven K. Derr, J.M. Dean, and Scott Sauter. 1976. CHRONIC TOXICITY OF LINDANE TO SELECTED AQUATIC INVERTEBRATES AND FISHES. Bionomics, E G & G, Inc., Wareham MA. Publication No. EPA-600/3-76-046. 58 p.

Representatives of the aquatic invertebrate species of water flea (Daphnia magna), midge (Chironomus tentans), and scud (Gammarus fasciatus) and the fish species of bluegill (Lepomis macrochirus), fathead minnow (Pimephales promelas), and brook trout (Salvelinus fontinalis) were chronically exposed to various concentrations of lindane in separate flowing water systems.

Maximum acceptable toxicant concentrations (MATC) of lindane for the selected species in soft water were estimated using survival, growth, and reproduction as indicators of toxic effects. The MATC was estimated to be between 2.2 and 5.0 µg/l for midges, between 11 and 19 µg/l for the water flea, and between 4.3 and 8.6 µg/l for the scud. For fishes the MATC was estimated between 9.1 and 12.5 µg/l for bluegills, between 9.1 and 23.5 µg/l for fathead minnows, and between 8.8 and 16.6 µg/l for brook trout. The incipient lethal concentration (LC50) for fishes and the 48-hour LC50 for invertebrates were estimated from acute exposures and used to calculate application factors (MATC/LC50). For aquatic invertebrates and lindane the estimated application

factors were between 0.010 and 0.024 for midges, between 0.020 and 0.029 for water flea, and between 0.11 and 0.22 for scud. Application factors were estimated between 0.30 and 0.42 for bluegill, between 0.13 and 0.34 for fathead minnows, and between 0.34 and 0.64 for brook trout.

Source: ERL-D -or-

NTIS, No. 256334/AS
Price: Paper copy $4.50, Microfiche $3.00

19 Macek, Kenneth J., Kenneth S. Buxton, Scott Sauter, Sarah Gnilka, and Jerry W. Dean. 1976. CHRONIC TOXICITY OF ATRAZINE TO SELECTED AQUATIC INVERTEBRATES AND FISHES. Biomics, E G & G, Inc., Wareham MA. Publication No. EPA-600/3-76-047. 58 p.

Representatives of the aquatic invertebrate species of water flea (Daphnia magna), midge (Chironomus tentans), and scud (Gammarus fasciatus); and the fish species bluegill (Lepomis macrochirus), fathead minnow (Pimephales promelas), and brook trout (Salvelinus fontinalis) were chronically exposed to various concentrations of atrazine in separate flowing-water systems.

Maximum acceptable toxicant concentrations (MATC) of atrazine for the selected species in soft water were estimated using survival, growth, and reproduction as indicators of toxic effects. The MATC was estimated to be between 0.11 and 0.23 mg/l for midges, between 0.14 and 0.25 mg/l for water fleas, and between 0.06 and 0.14 for the scud. For fishes the MATC was estimated to be between 0.09 and 0.50 mg/l for bluegills, between 0.21 and 0.52 mg/l for fathead minnows, and between 0.06 and 0.12 mg/l for brook trout. The incipient-LC50 for fishes and the 48-hour LC50 for invertebrates was estimated from acute exposures and was used to calculate application factors (MATC/LC50). For aquatic invertebrates and atrazine the estimated application factors were between 0.15 and 0.32 for midges, between 0.02 and 0.04 for water flea, and between 0.01 and 0.02 for scud. Application factors were estimated between 0.01 and 0.07 for bluegills, between 0.01 and 0.03 for fathead minnows, and between 0.01 and 0.02 for brook trout.

Source: ERL-D -or-

NTIS, No. PR255439/AS
Price: Paper copy $4.50, Microfiche $3.00

20 Macek, Kenneth J., Mark A. Lindberg, Scott Sauter, Kenneth S. Buxton, and Patricia A. Costa. TOXICITY OF FOUR PESTICIDES TO WATER FLEAS AND FATHEAD MINNOWS -- ACUTE AND CHRONIC TOXICITY OF ACROLEIN, HEPTACHLOR, ENDOSULFAN, AND TRIFLURALIN TO THE WATER FLEA (DAPHNIA MAGNA) AND THE

FATHEAD MINNOW (PIMEPHALES PROMELAS). Bionomics, E G & G, Inc., Wareham MA. Publication No. EPA-600/3-76-099. 67 p.

Maximum acceptable toxicant concentrations (MATC's) for each pesticide for both species were estimated by measuring survival, growth and reproduction success as indicators of toxic effects. The MATC for acrolein was estimated to be >16.9 and <33.6 µg/l for daphnids and >11.4 and <41.7 for fathead minnows, those estimated for heptachlor were >12.5 and <25.0 µg/l for daphnids and >0.86 and <1.84 µg/l for fathead minnows, those estimated for endosulfan were >2.7 and <7.0 µg/l for daphnids and >0.2 and <0.4 µg/l for fathead minnows, and those estimated for trifluralin were >2.4 and <7.2 µg/l for daphnids and >1.9 and <5.1 µg/l for fathead minnows.

Source: ERL-D -or- NTIS

21 Mattson, Vincent R., John W. Arthur, and Charles T. Walbridge. 1976. ACUTE TOXICITY OF SELECTED ORGANIC COMPOUNDS TO FATHEAD MINNOWS. Environmental Research Laboratory, Duluth MN. Publication No. EPA-600/3-76-097. 13 p.

Static nonrenewal laboratory bioassays were conducted with 26 organic compounds commonly used by industry. The selected compounds represented the five following chemical classes: acids, alcohols, hydrocarbons, ketones and aldehydes, and phenols. Juvenile fathead minnows (Pimephales promelas) were the test animal, and test duration was limited to 96 hours. Lake Superior water served as the diluent source for all test compounds. Additional tests were conducted with a reconstituted diluent water for five compounds. The alcohol compounds were generally 10 to 100 times less toxic than chemicals tested in the other four chemical classes. Compounds in the other four classes had a similar toxicity range. The most lethal chemical tested was pentachlorophenol (96-hr LC50 of 0.6 mg/l.) and the least lethal was ethanol (96-hr LC50 of 13,480 mg/l.). Most of the minnow deaths occurred during the first 24 hr. Comparative chemical tests in the two diluent waters gave similar lethal responses.

Source: ERL-D -or- NTIS

22 McCormick, J. Howard. 1976. TEMPERATURE EFFECTS ON YOUNG YELLOW PERCH, PERCA FLAVESCENS (MITCHILL). Environmental Research Laboratory, Duluth MN. Publication No. EPA-600/3-76-057. 25 p.

The effect of temperature on growth of young-of-the-year yellow perch was determined over an 8-week period at constant temperatures from 8 to 34 C. Absolute growth rates peaked at 28 C, but were not significantly less (P>0.05) over the range from 26 to 30 C. Deformities occurred at 32 C but at no lower temperatures, and all fish died within 7 days at 34 C. A

suggested seasonal temperature cycle for yellow perch habitats is presented, based on the data from this experiment for the summer period of rapid growth and on data from previous studies for other life stages.

Source: ERL-D -or-

NTIS, No. 253169/AS
Price: Paper copy $3.50, Microfiche $3.00

23 Peterka, John J. and James S. Kent. DISSOLVED OXYGEN, TEMPERATURE, SURVIVAL OF YOUNG AT FISH SPAWNING SITES. 1976. North Dakota State University, Fargo ND. Publication No. EPA-600/3-76-113. 43 p.

Fluctuations of dissolved oxygen concentrations and water temperatures in their natural spawning sites were measured during embryo through larva stages of northern pike (Esox lucius), and during embryo and sac larva stages of bluegills (Lepomis macrochirus) and pumpkinseeds (Lepomis gibbosus). At northern pike sites, dissolved oxygen concentrations from combined measurements 1 and 10 cm from the bottom ranged from 0.0-16.6 mg/liter, and water temperatures from 2.5-23.0 C; average daily fluctuations were 3.0 mg/liter and 1.6 C. For bluegill and pumpkinseed nests, dissolved oxygen concentrations 1 cm from the bottom ranged from 2.4-18.2 mg/liter and water temperatures from 15.0-27.5 C, with average daily fluctuations of 4.4 mg/liter and 3.3 C. In field experiments to determine acute effects of a single exposure to low dissolved oxygen concentrations, tolerance decreased from embryo to larva stages for northern pike and from embryo to sac larva stages from bluegills and smallmouth bass (Micropterus dolomieui).

Source: ERL-D -or- NTIS

24 Samuelson, Donald F. 1976. WATER QUALITY: WESTERN FISH TOXICOLOGY STATION AND WESTERN OREGON RIVERS. Western Fish Toxicology Station, Corvallis OR (formerly a field station of the Environmental Research Laboratory, Duluth MN). Publication No. EPA-600/3-76-077. 56 p.

Seasonal variation in water quality was compared for the Western Fish Toxicology Station (WFTS), Corvallis, OR, the adjacent Willamette River and approximately 40 major western Oregon rivers from 1972 through 1974.

Water temperature patterns of the Willamette River and the WFTS well were similar (range, 4.6-20.0 C). While both displayed seasonal trends, well water lagged 7-10 days behind the river in both temperature increases and decreases. Dissolved oxygen values in both the river and well water were inversely related to temperature. Average dissolved oxygen concentrations were higher in the river (10.4 mg/l) than in the well water (4.1 mg/l). Hydrogen ion concentration (pH) was low in the well water (range, 6.6-7.0), compared to the river (range, 7.0-7.8). River water

had a mean hardness and alkalinity of 22 mg/l and 23 mg/l, respectively, while water ranged between "soft to moderately hard" (mean hardness, 34 mg/l; mean alkalinity, 31 mg/l). High Willamette River discharges (above Corvallis) were followed by 7-10 day lags in corresponding sharp peaks of total hardness, alkalinity, and certain cations and anions in the well water. Major cation and anion concentrations were low overall. Trace metals were found to be at or near detection limits. River iron and manganese concentrations were approximately 10 times greater than those found in the well. River zinc had a mean of 9.4 µg/l, while the well water mean concentration was 5.1 µg/l.

Source: ERL-D -or- NTIS

25 Sauter, Scott, Kenneth S. Buxton, Kenneth J. Macek and Sam R. Petrocelli. 1976. EFFECTS OF EXPOSURE TO HEAVY METALS ON SELECTED FRESHWATER FISH. Bionomics, E G & G, Inc., Wareham MA. Publication No. EPA-600/3-76-105. 85 p.

Embryo and larvae of rainbow trout, lake trout, channel catfish, bluegill, white sucker, northern pike, and walleye were exposed for 60 days after hatch to lead and chromium in soft water. Brook trout, channel catfish, and walleyes were also exposed for 60 days after hatch to copper and cadmium in soft and hard water. The effects on survival and growth indicated that copper and cadmium were toxic at much lower concentrations than lead and chromium. Water hardness did not appear to have a significant effect on the observed toxicity in most cases.

Source: ERL-D -or- NTIS

26 Schelske, C.L., E.F. Stoermer, J.E. Gannon and M.S. Simmons. 1976. BIOLOGICAL, CHEMICAL AND PHYSICAL RELATIONSHIPS IN THE STRAITS OF MACKINAC. University of Michigan, Ann Arbor, MI. Publication No. EPA-600/3-76-095. 278 p.

Three cruises were conducted from August to October 1973 in the vicinity of the Straits of Mackinac. Environmental conditions were influenced by the net transport of water from Lake Michigan to Lake Huron, the oscillatory flow of water produced by seiches between the two lakes, and the hypolimnetic transport of water from Lake Huron to Lake Michigan during periods of thermal stratification. Different water masses resulted from the mixing of waters from Lake Huron, Lake MIchigan and Lake Superior and were identified from single parameters, particularly silica, nitrate, pH, temperature and specific conductance, from cluster analysis of chemical and physical parameters and from ordination analyses of phytoplankton and zooplankton assemblages.

Lake Michigan waters transported through the Straits represent a diffuse and relatively small phosphorus enrichment for Lake

Huron, but were depleted in silica and nitrate compared to Lake Huron. In August and September phytoplankton in the silica depleted waters from Lake Michigan were dominated by blue-green algae. The phytoplankton assemblages in the Straits were distinct from those in the open waters of Lake Michigan and Lake Huron. Zooplankton species composition was similar at the 50 stations sampled, but cladocerans were proportionately more prevalent in the more eutrophic waters of Lake Michigan than were calanoid copepods in Lake Huron. In was concluded that water from Lake Michigan had a subtle delterious effect on water quality in Lake Huron.

Source: LLRS -or- NTIS

27 Smith, Lloyd L., Jr., Donavon M. Oseid, Ira R. Adelman, and Steven J. Broderius. 1976. EFFECT OF HYDROGEN SULFIDE ON FISH AND INVERTEBRATES, PART I---ACUTE AND CHRONIC TOXICITY STUDIES. University of Minnesota, St. Paul MN. Publication No. EPA-600/3-76-062a. 302 p.

Acute and chronic toxicity of hydrogen sulfide to seven fish species and eight invertebrates were determined in continuous-flow bioassays. Fish species were fathead minnows, goldfish, bluegill, walleye, white sucker, brook trout, and rainbow trout. Invertebrates were Asellus, Crangonyz, Gammarus, Baetis, Hexagenia, Ephemera, Procambarus, and Cambarus. In 159 acute tests lethal threshold concentration for juvenile fish varied from 0.0087 mg/l in rainbow trout to 0.0840 mg/l in goldfish. Except in goldfish, fry stage was up to three times more sensitive than the juvenile. In 96 tests on invertebrates the 96-hr LC50 ranged from 0.020 mg/l in Baetis to 1.070 mg/l in Asellus. Acute toxicity of H_2S to fathead minnows varied 24-fold between 6.5 and 24.0 C. Temperature effects were not as marked on invertebrates. In chronic exposure to H_2S in 29 tests running up to 825 days, maximum no-effect concentration to fish ranged from 0.0004 mg/l in bluegills to 0.0100 mg/l in goldfish. No-effect level was determined from growth, survival, reproduction, or swimming performance. In nine chronic tests running up to 138 days, maximum safe levels ranged from 0.0012 mg/l in Gammarus to 0.0152 mg/l in Hexagenia. Application factors relating acute toxic (96-hr LC50 for juveniles) to no-effect levels varied from .231 in rainbow trout to .013 in bluegills and from .091 in Gammarus to .048 in Procambarus.

Source: ERL-D -or-

NTIS, No. PB256410/AS
Price: Paper copy $9.75, Microfiche $3.00

28 Snarski, Virginia M., and Frank A. Puglisi. 1976. EFFECTS OF AROCLOR® 1254 ON BROOK TROUT, SALVELINUS FONTINALIS. Environmental Research Laboratory, Duluth MN. Publication No. EPA-600/3-76-112. 41 p.

No adverse effects were observed on survival, growth, and reproduction of brook trout exposed for 71 weeks to 0.94 µg/l and lower concentrations of the polychlorinated biphenyl Aroclor® 1254 (P = 0.05). Survival and growth to 90 days of alevin-juveniles from exposed parents were also unaffected (P = 0.05). Polychlorinated biphenyl concentrations in the brook trout were directly proportional to the water exposure concentrations (P = 0.05). The PCB tissue concentrations appeared to have reached a steady state by the first sampling after 14 weeks of exposure. The PCB residues (wet-tissue basis) in chronically exposed fish were approximately 2 µg/g in the fillet and 9 µg/g in the "whole body" (entire fish minus one fillet and the gonads) at the highest water concentration, 0.94 µg/l. The higher residue in the whole body compared to the corresponding fillet was due to the higher fat content of the former.

Source: ERL-D -or- NTIS

29 Spehar, Robert L. 1976. CADMIUM AND ZINC TOXICITY TO JORDANELLA FLORIDAE. Environmental Research Laboratory, Duluth MN. Publication No. EPA-600/3-76-096. 34 p.

Cadmium and zinc toxicity to the flagfish (Jordanella floridae) was determined on the basis of 96-hr median lethal concentrations (LC50) and significant decreases (P = 0.05) in survival, growth, and reproduction over the complete life cycle of the fish. The 96-hr LC50 values for cadmium and zinc to juvenile flagfish were 2,500 and 1,500 µg/liter, respectively. In chronic tests, reproduction was the most sensitive indicator of cadmium toxicity and was inhibited at 8.1 µg/liter. Tissue-concentration analysis showed that fish exposed to concentrations of 1.7 µg/liter and above accumulated significantly greater amounts of cadmium than those in the controls. In zinc tests, survival of larvae (not exposed as embryos) and growth of females were the most sensitive measure of zinc toxicity and were reduced at respective concentrations of 85 and 51 µg/liter. Significant uptake of zinc occurred in fish exposed to concentrations of 47 µg/liter and above. The lowest cadmium and zinc concentrations causing adverse effects to the flagfish were similar to those affecting other fish species. Application factors for both metals were similar to those reported for cadmium exposed bluegills (Lepomis macrochirus) and zinc exposed fathead minnows (Pimephales promelas) in hard water.

Source: ERL-D -or- NTIS

30 Stalling, David L. and James N. Huckins. 1976. ANALYSIS AND GC-MS CHARACTERIZATION OF TOXAPHENE IN FISH AND WATER. Fish-Pesticide Research Laboratory, Columbia MO. Publication No. EPA-600/3-76-076. 53 p.

The report describes sensitive methods for the detection and identification of toxaphene in water and fish. The authors used

polyurethane foam, gel permeation, and silicic acid chromatography to accurately quantitate multi-component toxaphene residues. They report a method for characterizing changes in the isomer composition of toxaphene residues in fish. The chemical composition of toxaphene was examined by electron impact and chemical ionization mass spectrometry. Chemical ionization gas chromatography-mass spectrometry was particularly applicable to the analysis and confirmation of toxaphene in residues in environmental samples.

Source: ERL-D -or-

NTIS, No. PB25773/AS
Price: Paper copy $4.50, Microfiche $3.00.

31 Thomann, Robert V., Richard P. Winfield, Dominic M. DiToro, and Donald J. O'Connor. 1976. MATHEMATICAL MODELING OF PHYTOPLANKTON IN LAKE ONTARIO, PART 2. SIMULATIONS USING LAKE 1 MODEL. Manhattan College, Bronx NY. Publication No. EPA-600/3-76-065. 97 p.

The results of a series of simulations of the response of the open lake region of Lake Ontario to various levels of nutrient input are described. The simulations use a simplified dynamic model of phytoplankton - nutrient interactions in a vertically segmented structure. The analysis of long term simulations (10-20 years) indicates that the overall nutrient loss rates are of particular importance. Under a reasonable set of model parameters, the simulations indicate that the present observed open lake phytoplankton biomass of Lake Ontario apparently is not in equilibrium with the present input nutrient load. Therefore, if the present load is continued, it is estimated that spring peak phytoplankton chlorophyll in the epilimnion will continue to increase to a new level about 45% higher than present levels. The interaction of nitrogen and phosphorus is also described by the simulations, and the results indicate a tendency for nitrogen limitation to be an increasingly dominant factor in controlling the spring bloom. An estimated "pastoral" load simulation, indicative of conditions prior to man's intensive activity, indicates that spring phytoplankton levels were some 40% less than present levels, and average annual epilimnion biomass under equilibrium with present loads is about twice that under pastoral conditions.

Source: ERL-D -or-

NTIS, No. PB258189/AS
Price: Paper copy $5.00, Microfiche $3.00.

32 Winner, Robert W. 1976. TOXICITY OF COPPER TO DAPHNIDS IN RECONSTITUTEDAND NATURAL WATERS. Miami University, Oxford OH. Publication No. EPA-600/3-76-051. 79 p.

The toxicity of copper was compared for Daphnia magna cultured in reconstituted versus pond water and fed on trout-pellet versus vitamin-enriched algal foods. Effects of a chronic copper stress were highly variable when animals were tested in reconstituted waters. This variability is thought to be due to variability in the quality of the distilled-water matrix. The vitamin-enriched algal food was found to be superior to the trout-granule food in culturing D. magna. Control animals lived much longer and test animals were less sensitive to a chronic copper stress. The acute and chronic toxicity of copper was also compared for four species of Daphnia. When tested in pond water and fed vitamin-enriched algae, the two largest species (D. magna and D. pulex) were significantly less sensitive to an acute copper stress than the two smallest species (D. parvula and D. ambigua). There was, however, no significant difference in sensitivity to a chronic copper stress when reduced longevity was used as the index. Application factors for the four species varied from 0.47 to 0.62 and were not significantly different.

Source: ERL-D -or-

NTIS, No. PB252915/AS
Price: Paper copy $5.00, Microfiche $3.00

1969

33 University of Michigan. 1969. PLANKTON DIATOM ASSEMBLAGES IN LAKE MICHIGAN. University of Michigan, Ann Arbor MI. Publication No. 18050DKC12/69. 273 p.

Source: ERL-D -or-

NTIS, No. PB198087
Price: Paper copy $9.00, Microfiche $3.00

1970

34 Arthur D. Little, Incorporated. 1970. WATER QUALITY CRITERIA DATA BOOK, VOLUME I. ORGANIC CHEMICAL POLLUTION OF FRESHWATER. Arthur D. Little, Incorporated, Cambridge MA. Publication No. 18010DPV12/70. 399 p.

Source: NTIS, No. PB208987
Price: Paper copy $10.75, Microfiche $3.00

35 DePauw University. 1970. EFFECT OF INORGANIC SEDIMENT ON STREAM BIOTA. DePauw University, Greencastle IN. Publication No. 18050DWC12/70. 150 p.

Source: NTIS, No. PB204236
Price: Paper copy $6.00, Microfiche $3.00

36 Fromm, Paul O. 1970. TOXIC ACTION OF WATER SOLUBLE POLLUTANTS ON FRESHWATER FISH. Michigan State University, East Lansing MI. Publication No. 18050DST12/70. 59 p.

Source: NTIS, No. PB201650
Price: Paper copy $4.50, Microfiche $3.00

1971

37 Arthur D. Little, Incorporated. 1971. WATER QUALITY DATA BOOK VOLUME 2. INORGANIC CHEMICAL POLLUTION OF FRESHWATER. Arthur D. Little, Incorporated, Cambridge MA. Publication No. 18010DPV07/71. 280 p.

Source: ERL-D -or-

NTIS, No. PB208988
Price: Paper copy $9.25, Microfiche $3.00

38 Battelle Columbus Laboratories. 1971. WATER QUALITY CRITERIA DATA BOOK VOLUME 3. EFFECTS OF CHEMICALS ON AQUATIC LIFE. Battelle Columbus Laboratories, Columbus OH. Publication No. 18050GWV05/71.

Source: NTIS, No. PB231210

39 Bureau of Sport Fisheries. 1971. STREAM FAUNAL RECOVERY AFTER MANGANESE STRIP MINE RECLAMATION. Virginia Polytechnic Institute, Blacksburg VA. Publication No. 18050DOH06/71. 41 p.

Source: ERL-D -or-

NTIS, No. PB206184
Price: Paper copy $4.00, Microfiche $3.00

40 Cairns, Jr., J. and R.E. Sparks. 1971. USE OF BLUEGILLS TO DETECT ZINC. Virginia Polytechnic Institute and State University, Blacksburg VA. Publication No. 18050EDQ12/71. 45 p.

Source: ERL-D -or-

NTIS, No. PB211332
Price: Paper copy $4.00, Microfiche $3.00

41 Cairns, Jr., J. and W.T. Waller. 1971. USE OF FISH MOVEMENT PATTERNS TO MONITOR ZINC. Virginia Polytechnic Institute and State University, Blacksburg VA. Publication No. 18050EDP12/71.

Source: NTIS, No. PB211333
Price: Paper copy $4.50, Microfiche $3.00

42 Dodd, J.D. 1971. ECOLOGY OF DIATOMS IN HARDWATER HABITATS. Iowa State University, Department of Botany and Plant Pathology, Ames IA. Publication No. 18050DIE12/71. 65 p.

Source: ERL-D -or-

NTIS, No. PB213005
Price: Paper copy $4.50, Microfiche $3.00

43 Illinois University. 1971. BIOLOGICAL SURVEY OF STREAMS OF COLES COUNTY, ILLINOIS, 1967-1970. Illinois University, Eastern Charleston IL. Publication No. 18050DZZ06/71.

Source: ERL-D

44 Michigan Department of Natural Resources. 1971. CHLORINATED MUNICIPAL WASTE TOXICITIES TO RAINBOW TROUT AND FATHEAD MINNOWS. Michigan Department of Natural Resources, Lansing MI. Publication No. 18050GZZ10/71.

Source: ERL-D -or-

NTIS, No. PB209890
Price: Paper copy $4.50, Microfiche $3.00

45 Pennsylvania State University. 1971. HISTOCHEMICAL AND CYTOPHOTOMETRIC ASSAY OF ACID STRESS IN FRESHWATER FISH. Pennsylvania State University, University Park PA. Publication No. 18050DXJ05/71. 123 p.

Source: ERL-D -or-

NTIS, No. PB227571
Price: Paper copy $5.50, Microfiche $3.00

46 Smith, R.W. and D.G. Frey. 1971. ACID MINE POLLUTION EFFECTS ON LAKE BIOLOGY. Indiana University, Water Resources Research Center, Bloomington IN. Publication No. 18050EEC12/71. 133 p.

Source: NTIS, No. PB210709
Price: Paper copy $6.00, Microfiche $3.00

47 Texas Christian University. 1971. INDUSTRIAL WASTES: EFFECTS ON TRINITY RIVER ECOLOGY, FORT WORTH, TEXAS. Department of Biology, Fort Worth TX. Publication No. 18050DBB12/71. 167 p.

Source: ERL-D -or-

NTIS, No. PB211167
Price: Paper copy $6.75, Microfiche $3.00

48 University of Washington. 1971. RESPONSES OF TELEOST FISH TO ENVIRONMENTAL STRESS. University of Washington, Seattle WA. Publication No. 18050EBK02/71. 130 p.

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AMERICA. Old Dominion University, Department of Biology, Norfolk VA. Publication No. 18050ELD04/71. 95 p.

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NTIS, No. PB246901/AS
Price: Paper copy $4.50, Microfiche $3.00

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Price: Paper copy $4.50, Microfiche $3.00

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Price: Paper copy $4.50, Microfiche $3.00

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Price: Paper copy $4.50, Microfiche $3.00

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Price: Paper copy $7.50, Microfiche $3.00

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NTIS, No. PB241635/AS
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JOURNAL ARTICLES

All articles in this section have been authored and published in the open scientific literature by staff members of the Duluth facility and its field stations. Limited quantities of reprints are available for some articles, and those publications identified as an ERL-D reprint can be requested by that number from the Environmental Research Laboratory-Duluth, 6201 Congdon Boulevard, Duluth MN 55804. All articles not identified as an ERL-D reprint can be seen in the professional journals held by most major libraries, particularly those at colleges and universities.

1976

98 Benoit, D.A. 1976. TOXIC EFFECTS OF HEXAVALENT CHROMIUM ON BROOK TROUT (SALVELINUS FONTINALIS) AND RAINBOW TROUT (SALMO GAIRDNERI). Water Res. 10: 497-500. (ERL-D Reprint #138)

Exposing brook trout to various concentrations of chromium [CR(VI)] for up to 22 months (including reproduction) significantly increased alevin mortality at 0.35 mg Cr/l and retarded growth of young brook trout at the lowest concentration tested (0.01 mg Cr/l). Eight month exposures of rainbow trout significantly increased alevin mortality at 0.34 mg Cr/l and also retarded growth at the lowest concentration tested (0.10 mg Cr/l). Exposures of brook trout lasting 22 months showed, however, that growth was only temporarily affected, and therefore it was not used as an end point to measure the effects of chromium on either species. Reproduction and embryo hatchability of brook trout were unaffected at Cr(VI) concentrations that affected survival of newly hatched alevins. The maximum acceptable toxicant concentration (MATC) for brook and rainbow trout exposed to Cr(VI) in water with a hardness of 45 mg/l (as $CaCO_3$) and a pH range of 7-8 lies between 0.20 and 0.35 mg Cr/l. The 96-h LC50 for brook and rainbow trout was 59 and 69 mg Cr/l, respectively; therefore, the application factor (MATC/96-h LC50) for both species lies between 0.003 and 0.006.

Source: ERL-D

99 Benoit, D.A., E.N. Leonard, G.M. Christensen, and J.T. Fiandt. 1976. TOXIC EFFECTS OF CADMIUM ON THREE GENERATIONS OF BROOK TROUT (SALVELINUS FONTINALIS). Trans. Am. Fish. Soc. 105(4): 550-560. (ERL-D Reprint #149)

Three generations of brook trout (Salvelinus fontinalis) were exposed to several concentrations of total cadmium (0.06-6.4 µg Cd/liter). Significant numbers of first- and second-generation adult males died during spawning at 3.4 µg Cd/liter. This concentration also significantly retarded growth of juvenile second- and third-generation offspring. The maximum acceptable toxicant concentration (MATC) for brook trout exposed to cadmium in Lake Superior water (hardness 44 mg/liter as $CaCO_3$, pH 7-8) lies between 1.7 and 3.4 µg Cd/liter. Cadmium-residue analyses of kidney, liver, and gill tissue accumulated the greatest amounts of cadmium at each water exposure concentration. No significant increases in cadmium were measured in edible muscle at any of the cadmium water concentrations tested. Cadmium residues in kidney, liver, and gill tissue of fish from all exposure concentrations reached equilibrium (µg Cd/g tissue) in both first- and second-generation trout after 20 weeks. Cadmium loss from gill tissue of second-generation trout placed in control water for 12 weeks was rapid; however, no loss was detectable from the liver and kidney.

Source: ERL-D

100 Biesinger, Kenneth E., Armond E. Lemke, Wesley E. Smith, and Robert M. Tyo. 1976. COMPARATIVE TOXICITY OF POLYELECTROLYTES TO SELECTED AQUATIC ANIMALS. J. Water Pollut. Control Fed. 48(1): 183-187. (ERL-D Reprint #137)

Although polyelectrolytes are widely used to control solids in potable water and municipal wastewater, very few studies have been made to assess their toxicity to aquatic animals. Consequently, the authors tested the acute toxicity of several polyelectrolytes to rainbow trout, lake trout, a mysid, a copepod, and a cladoceran in Lake Superior water. They also tested the chronic toxicity of three of these compounds to Daphnia magna to study possible effects on reproduction. Their results indicated that some of the cationic polyelectrolytes tested were toxic at concentrations that might cause serious problems to aquatic life.

Source: ERL-D

101 Brungs, W.A., J.R. Geckler, and M. Gast. 1976. ACUTE AND CHRONIC TOXICITY OF COPPER TO THE FATHEAD MINNOW IN A SURFACE WATER OF VARIABLE QUALITY. Water Res. 10(1): 37-43. (ERL-D Reprint #131)

Acute and chronic toxicity tests were conducted with the fathead minnow and copper. Used as the source of dilution water was a natural stream to which a sewage treatment plant upstream contributed a variety of materials known to affect acute copper toxicity. Nominal total copper 96-h median tolerance limit values (96-h TL50), determined with static testing procedures, ranged from 1.6 to 21 mg/l. Dissolved copper 96-h TL50 values

ranged from 0.60 to 0.98 mg/l. The maximum acceptable toxicant concentration (MATC) based on survival, growth, reproduction, and hatchability of eggs was between 0.066 and 0.118 mg/l.

Source: ERL-D

102 Christensen, G.M. and J.H. Tucker. EFFECTS OF SELECTED WATER TOXICANTS ON THE IN VITRO ACTIVITY OF FISH CARBONIC ANHYDRASE. Chem.-Biol. Interactions 13(2): 181-192. (ERL-D Reprint #135)

Carbonic anhydrase (CA, carbonate hydro-lyase EC 4.2.1.1) from lysed red blood cells of the channel catfish (Ictalurus punctatus) was studied to determine physico-chemical kinetic properties and relative sensitivity to 56 chemicals of significance in water quality research. In general, enzyme activity was strongly reduced by heavy metal inorganic cations; less strongly by organometallic cations, some anions, and certain pesticides; and weakly inhibited by light metal cations and organometallic and organic compounds. Dose - response curves were qualitatively similar in most cases.

Source: ERL-D

103 Holcombe, G.W., D.A. Benoit, E.N. Leonard, and J.M. McKim. 1976. LONG-TERM EFFECTS OF LEAD EXPOSURE ON THREE GENERATIONS OF BROOK TROUT (SALVELINUS FONTINALIS). J. Fish. Res. Board Can. 33(8): 1731-1741. (ERL-D Reprint #144)

Exposure of three generations of brook trout (Salvelinus fontinalis) to mean total lead concentrations (0.9-474 µg/l) showed that all second-generation trout exposed to 235 and 474 µg Pb/l and 34% of those exposed to 119 µg Pb/l developed severe spinal deformities (scoliosis). Scoliosis also appeared in 21% of the newly hatched third-generation alevins exposed to 119 µg Pb/l, and weights of these fish 12 wk after hatch were significantly reduced. Gill, liver, and kidney tissues of first- and second-generation brook trout accumulated the greatest amount of lead. Only small amounts accumulated in the edible muscle. An equilibrium of lead residues was reached in liver and kidney tissue from second-generation fish after 70 wk of exposure, but not in gill tissue. Fish exposed to 119 µg Pb/l and then placed in uncontaminated control water for 12 wk showed a 70, 78, and 74% loss in micrograms Pb per gram for gill, liver, and kidney tissue, respectively, and a 39, 56, and 35% loss, respectively, in the total micrograms of Pb in the whole tissue. Residue analysis of eggs, alevins, and juveniles showed that lead was accumulated during these life stages. The maximum acceptable toxicant concentration (MATC) for brook trout in water with a hardness of 44 mg/l (as $CaCO_3$) and a pH of 6.8-7 lies between 59 and 119 µg/l for total lead and between 39 and 84 µg/l for dissolved lead. The MATC was based on the development of

scoliosis in second- and third-generation fish and the reduced total growth of 12-wk-old third-generation trout.

Source: ERL-D

104 Kuehl, D.W., H.L. Kopperman, G.D. Veith, and G.E. Glass. 1976. ISOLATION AND IDENTIFICATION OF POLYCHLORINATED STYRENES IN GREAT LAKES FISH. Bull. Environ. Contam. Toxicol. 16(2): 127-132. (ERL-D Reprint #141)

A previously unreported compound type, the polychlorinated styrenes, have been isolated and identified in fish from Lake Ontario, Lake Huron, and the Detroit River. Octachlorostyrene has been synthesized to confirm its presence by gas chromatographic and mass spectral data.

Source: ERL-D

105 McCormick, J. Howard and Charles F. Kleiner. 1976. GROWTH AND SURVIVAL OF YOUNG-OF-THE-YEAR EMERALD SHINERS (NOTROPIS ATHERINOIDES) AT DIFFERENT TEMPERATURES. J. Fish Res. Board Can. 33(4): 839-842. (ERL-D Reprint #136)

Young-of-the-year emerald shiners (Notropis atherinoides) were exposed to mean constant temperatures of 6.9, 11.9, 16.0, 19.8, 24.0, 26.9, 28.9, 31.0, 32.8, 34.9 and 36.7 C for 6 wk. Maximum rates of growth and net biomass gain occurred at 28.9 C, but these rates were not statistically greater ($P>0.05$) than those at 26.9 and 24.0 C. Death rates were low at test temperatures up to 32.8 C but high at 34.9 C and above. The upper incipient 7-day TL50 was estimated to be 35.2. The 1-day TL50 of fish taken from the natural habitat, where peak daily temperatures ranged between 20 and 25 C during the preceding few days, was 32.6 C. Natural production of this important forage species would probably be best where temperatures are at least 19 C but not above 29 C for extended periods.

Source: ERL-D

106 McKim, J.M., R.L. Anderson, D.A. Benoit, R.L. Spehar, and G.N. Stokes. 1976. EFFECTS OF POLLUTION ON FRESHWATER FISH. J. Water Pollut. Control Fed. 48(6): 1544-1620. (ERL-D Reprint #139)

This extensive literature review, including 480 references, discusses the effects of pollutants (metals, pesticides, detergents, industrial wastes) on freshwater fish. Other topics include chemical and biological methods for identifying and determining the effects of such pollutants and the effects of the water quality parameters (salinity, oxygen, and pH) on freshwater fish.

Source: ERL-D

107 McKim, J.M., G.F. Olson, G.W. Holcombe, and E.P. Hunt. 1976. LONG-TERM EFFECTS OF METHYLMERCURIC CHLORIDE ON THREE GENERATIONS OF BROOK TROUT (SALVELINUS FONTINALIS): TOXICITY, ACCUMULATION, DISTRIBUTION, AND ELIMINATION. J. Fish. Res. Board Can. 33: 2726-2739. (ERL-D Reprint #150)

During a 144-wk period three generations of brook trout (Salvelinus fontinalis) were continuously exposed to mean water concentrations of methymercuric chloride (MMC) of 2.93, 0.93, 0.29, 0.03, and 0.010 (control) µg Hg/liter. During the first 39 wk, the highest concentration (2.93 µg Hg/liter) produced deformities and 88% mortality of first-generation adults. At an MMC concentration of 0.93 µg Hg/liter, second-generation trout developed deformities and all but one female died during the 108 wk exposure. No significant effects on survival, growth, or reproduction of second-generation trout were noted at any of the lower MMC concentrations. No toxic symptoms were observed in the third generation at the three lowest MMC concentrations. The maximum acceptable toxicant concentration (MATC) for brook trout exposed to MMC in this water with a hardness of 45 mg/liter (as $CaCO_3$) and a pH of 7.5 fell between 0.93 and 0.29 µg Hg/liter. The mean 96-h LC50 for yearling (200 g) and 20-wk-old (12 g) juvenile brook trout exposed to MMC was 75.0 µg Hg/liter, and the application factor (MATC/96-h LC50) lies between 0.004 and 0.013. The accumulation rate of mercury by eight selected tissues of first-generation trout exposed to MMC was relatively rapid at all MMC concentrations tested. The 2-wk tissue Hg:water Hg concentration factors ranged from 1×10^3 to 12×10^3, depending on the tissue, whereas after 28 to 38 wk of exposure the maximum tissue Hg:water Hg concentration factors for both first- and second-generation trout ranged from 6.9×10^3 to 6.3×10^4.

Source: ERL-D

108 Nebeker, A.V. 1976. SURVIVAL OF DAPHNIA, CRAYFISH, AND STONEFLIES IN AIR-SUPERSATURATED WATER. J. Fish. Res. Board Can. 33(6): 1208-1212. (ERL-D Reprint #150)

Daphnia magna, the crayfish Pacifastacus leniusculus, and nymphs of the stoneflies, Acroneuria californica, A. pacifica, and Pteronarcys californica were tested in the laboratory to determine their survival in different concentrations of air-supersaturated water. The mean 96-h LC50 value (lethal concentration, 50% mortality) for D. magna was 122.5% total air saturation. The 7-day LC50 was 120% and the 10-day LC50 was 117.5%. The mean 96-h LC50 for crayfish was 147% total air saturation. The 7-day LC50 was 145% and the 10-day LC50 was 133%. The 10-day EC50 values (effective concentration, 50% immobilized) for stoneflies were 135% for A. californica and greater than 125% for A. pacifica and P. californica. Bubbles (emboli) were observed in body fluids and tissues, and general body distention occurred before death om Daphnia, crayfish,

and stoneflies. Lethal threshold concentrations for Daphnia and crayfish were near 111 and 127%, respectively.

Source: ERL-D Librarian

109 Smith, Wesley E. 1976. LARVAL FEEDING AND RAPID MATURATION OF BLUEGILLS IN THE LABORATORY. Prog. Fish-Cult. 38(2): 95-97. (ERL-D Reprint #148)

Bluegill larvae were raised in the laboratory with a high percentage of survival using newly hatched San Francisco brine shrimp nauplii as a first food. Utah brine shrimp nauplii and older San Francisco nauplii were too large for a bluegill first food. Bluegills were raised to maturity in 4-6 months.

Source: ERL-D

110 Spehar, Robert L. 1976. CADMIUM AND ZINC TOXICITY TO JORDANELLA FLORIDAE. J. Fish Res. Board Can. 33: 1939-1945. (ERL-D Reprint #145)

Cadmium and zinc toxicity to the flagfish (Jordanella floridae) was determined on the basis of 96-h median lethal concentrations (LC50) and significant decreases (P = 0.05) in survival, growth, and reproduction over the complete life cycle of the fish. The 96-h LC50 values for cadmium and zinc to juvenile flagfish were 2,500 and 1,500 µg/l, respectively. In chronic tests, reproduction was the most sensitive indicator of cadmium toxicity and was inhibited at 8.1 µg/l. Tissue-concentration analysis showed that fish exposed to concentrations of 1.7 µg/l and above accumulated significantly greater amounts of cadmium than those in the controls. In zinc tests, survival of larvae (not exposed as embryos) and growth of females were the most sensitive measure of zinc toxicity and were reduced at respective concentrations of 85 and 51 µg/l. Significant uptake of zinc occurred in fish exposed to concentrations of 47 µg/l and above. The lowest cadmium and zinc concentrations causing adverse effects to the flagfish were similar to those affecting other fish species. Application factors for both metals were similar to those reported for cadmium exposed bluegills (Lepomis macrochirus) and zinc exposed fathead minnows (Pimephales promelas) in hard water.

Source: ERL-D

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208 Glass, Gary E. and John E. Poldoski. 1975. INTERSTITIAL WATER COMPONENTS AND EXCHANGE ACROSS THE WATER SEDIMENT INTERFACE OF WESTERN LAKE SUPERIOR. Verh. Internat. Verein. Limnol. 19: 405-420. (ERL-D Reprint #127)

209 McKim, James M., John H. Arthur and Todd W. Thorslund. 1975. TOXICITY OF A LINEAR ALKYLATE SULFONATE DETERGENT TO LARVAE OF FOUR SPECIES OF FRESHWATER FISH. Bull. Environ. Contam. Toxicol. 14(1): 1-7. (ERL-D Reprint #125)

210 McKim, James M., Duane A. Benoit, Kenneth E. Biesinger, William A. Brungs and Richard E. Siefert. 1975. EFFECTS OF POLLUTION ON FRESHWATER FISH. J. Water Pollut. Control Fed. 47(6): 1711-1820. (ERL-D Reprint #123)

211 Olson, Gayle F., Donald I. Mount, Virginia M. Snarski and Todd W. Thorslund. 1975. MERCURY RESIDUES IN FATHEAD MINNOWS, PIMEPHALES PROMELAS RAFINESQUE, CHRONICALLY EXPOSED TO METHYLMERCURY IN WATER. Bull. Environ. Contam. Toxicol. 14(2): 129-134. (ERL-D Reprint #126)

212 Syrett, Roll F. and Walter F. Dawson. 1975. AN INEXPENSIVE SOLID-STATE TEMPERATURE CONTROLLER. Prog. Fish-Cult. 37(3): 171-172. (ERL-D Reprint #134)

213 Veith, Gilman D. 1975. BASELINE CONCENTRATIONS OF POLYCHLORINATED BIPHENYLS AND DDT IN LAKE MICHIGAN FISH, 1971. Pestic. Monit. J. 9(1): 21-29. (ERL-D Reprint #130)

214 Veith, Gilman D. and V.M. Comstock. 1975. APPARATUS FOR CONTINUOUSLY SATURATING WATER WITH HYDROPHOBIC ORGANIC CHEMICALS. J. Fish. Res. Board Can. 32(10): 1849-1851. (ERL-D Reprint #129)

215 Veith, Gilman D., Douglas W. Kuehl and Jeffrey Rosenthal. 1975. PREPARATIVE METHOD FOR GAS CHROMATOGRAPHIC/MASS SPECTRAL ANALYSIS OF TRACE QUANTITIES OF PESTICIDES IN FISH TISSUE. J. Assoc. Off. Anal. Chem. 58(1): 1-5. (ERL-D Reprint #118)

OTHER SCIENTIFIC PUBLICATIONS

The various materials in this section---primarily papers published in conference and meeting proceedings---all are authored by staff members of the Duluth facility and its field stations. Selected articles are available in limited quantities from the sources indicated. When requesting articles identified as ERL-D reprints, be sure to specify that number.

1976

216 Bierman, V.J., Jr. 1976. MATHEMATICAL MODEL OF THE SELECTIVE ENHANCEMENT OF BLUE-GREEN ALGAE BY NUTRIENT ENRICHMENT. In: Modeling Biochemical Processes in Aquatic Ecosystems (R.P. Canale, ed.). Ann Arbor Science Publishers, Inc., Ann Arbor MI. pp. 1-31.

A mathematical model of phytoplankton growth, which includes four separate functional groups, is used to investigate the relative importance of various processes in providing competitive advantages for the development of blue-green algae under conditions of nutrient enrichment. Preliminary simulations using data from Saginaw Bay, Lake Huron, are presented as a first application of the model. These results are then used as a baseline against which the results of various sensitivity analyses are compared. These analyses include effects of changes in phosphorus recycle, phosphorus uptake affinities, cell sinking rates, and zooplankton grazing. A hypothetical batch system is used to investigate the additional effects of changes in hydraulic detention time and phosphorus input dynamics.

Source: LLRS

217 Bierman, V.J., Jr. and D.M. Dolan. 1976. MATHEMATICAL MODELING OF PHYTOPLANKTON DYNAMICS IN SAGINAW BAY, LAKE HURON. Proc. Conf. on Environmental Modeling and Simulation, Cincinnati, Ohio, April 19-22. U.S. Environmental Protection Agency, Cincinnati OH. Publication No. EPA-600/9-76-016. pp. 773-779.

The authors applied a mathematical model of phytoplankton production to a set of physical, chemical, and biological data from Saginaw Bay, Lake Huron. The model includes five phytoplankton types, two zooplankton types, and three nutrients: phosphorus, nitrogen, and silicon. The phytoplankton types include diatoms,

greens, both nitrogen-fixing and non-nitrogen fixing blue-greens, and "others". The paper illustrates the use of the model in both research and management applications. A major research use is the interpretation of experimental data, such as the calibration of model output for total phosphorus concentration to actual field data. This calibration indicated the possibility of a previously unconsidered phosphorus source influencing the bay in the fall of 1974. An important management application is the model as a tool for comparing the effects of various wastewater management strategies such as simulating differences in response among the various phytoplankton types as a function of nutrient load reduction in Saginaw Bay. These examples and others are discussed in the paper.

218 Bierman, V.J., Jr. and W.L. Richardson. 1976. MATHEMATICAL MODEL OF PHYTOPLANKTON GROWTH IN SAGINAW BAY, LAKE HURON. In: Water Quality Criteria Research of the U.S. Environmental Protection Agency. U.S. Environmental Protection Agency, Corvallis, OR. Publication No. EPA-600/3-76-079. pp. 159-173.

The authors applied a phytoplankton model -- using diatoms, green algae, and two types of blue-green algae -- to a set of experimental data from Saginaw Bay. The model output agreed reasonably well with the data for phytoplankton chlorophyll, total nitrogen, and dissolved nutrients. However, it did not agree with total phosphorus during the latter part of the year, nor with total zooplankton. The most serious problem in the study was the lack of data for phytoplankton cell volumes at the species level.

219 Cook, Philip M., Ivan B. Rubin, Carl J. Maggiore, and William J. Nicholson. 1976. X-RAY DIFFRACTION AND ELECTRON BEAM ANALYSIS OF ASBESTIFORM MINERALS IN LAKE SUPERIOR WATERS. The Institute of Electrical and Electronics Engineers, Inc., New York NY. Annals No. 75CH1004-I 34-1. (ERL-D Reprint #133)

Western Lake Superior water, which is used for municipal water supplies, contains large concentrations of asbestiform amphibole fibers because of a taconite tailings discharge at Silver Bay, Minnesota. Large fluctuations in fiber concentrations are attributable to seasonal and meteorological changes which influence Western Lake Superior water circulation. Variations in electron microscope amphibole fiber counts generally correspond to variations in amphibole mass concentration determined by x-ray diffraction. Daily x-ray diffraction and occasional transmission electron microscope measurements of Duluth, Minnesota drinking water samples allows an estimate of the average (45-100 million) and the range (10-1000 million) of identifiable amphibole fibers per liter of water. Not all the amphibole fibers present can be identified due to their extremely small width.

Source: ERL-D

220 DePinto, J.V., V.J. Bierman, Jr., and F.H. Verhoff. 1976. SEASONAL PHYTOPLANKTON SUCCESSION AS A FUNCTION OF SPECIES COMPETITION FOR PHOSPHORUS AND NITROGEN. In: Modeling Biochemical Processes in Aquatic Ecosystems (R.P. Canale, ed.). Ann Arbor Science Publishers, Inc., Ann Arbor MI. pp. 141-169.

A mathematical model of phytoplankton growth, which includes three separate functional groups, was used as a research tool to investigate seasonal phytoplankton dynamics in Stone Lake, Cassopolis, Michigan. The data indicated that dissolved phosphorus is present in non-rate-limiting concentrations in the lake. Low dissolved nitrogen concentrations in early summer results in large blooms of nitrogen-fixing blue-green algae. In turn, the apparent rapid regeneration of dissolved nitrogen from the decline of this bloom results subsequently in a large bloom of non-nitrogen-fixing blue-green algae. Initial attempts to model these data were unsuccessful due to the rapid decline of these blooms. Various phytoplankton decay mechanisms were hypothesized and tested with the model. The results were consistent with the hypothesis that heterotrophic bacterial populations could be a significant factor in causing the observed rapid declines of the algal blooms and the subsequent nitrogen regeneration. However, alternative explanations for these phenomena could not be eliminated in the present study.

Source: LLRS

221 Kopperman, H.L., D.W. Kuehl, and G.E. Glass. 1976. CHLORINATED COMPOUNDS FOUND IN WASTE-TREATMENT EFFLUENTS AND THEIR CAPACITY TO BIOACCUMULATE. Proc. Conf. on the Environmental Impact of Water Chlorination (R.L. Jolley, ed.), Oak Ridge, Tennessee, October 22-24, 1975. (ERL-D Reprint #112)

The incorporation of chlorine into compounds during the disinfection of waste effluents with chlorine is an undesirable end result of effluent treatment due to an increase in the persistence of the chloro-organics and their ability to bioaccumulate. The problems that arise with bioaccumulation of organic compounds are generally not immediately apparent, and a major segment of the ecosystem may be contaminated before the problem is recognized. A discussion of chlorinated compounds found in waste-treatment effluents and their capacity to bioaccumulate is presented. Attention is especially drawn to an unreported compound type, the chloroanisoles.

Source: ERL-D

222 Poldoski, J.E. and G.E. Glass. 1976. METHODOLOGICAL CONSIDERATIONS IN WESTERN LAKE SUPERIOR WATER-SEDIMENT EXCHANGE STUDIES OF SOME TRACE

ELEMENTS. In: Accuracy in Trace Analysis: Sampling, Sample Handling, and Analysis. Proc. 7th IMR Symposium, Gaithersburg, Maryland, October 7-11, 1974. National Bureau of Standards Special Publication 422. pp. 1073-1088.

Trace element measurements on western Lake Superior water were taken as a function of geographical area and distance above and below the water-sediment interface. The objective of detecting gradients of certain constituents in the system, however, required an extensive examination of required methodology. Investigations of this methodology indicate that the values obtained from a particular sample type are constrained by a number of uncertainties and operational definitions. Data were taken using different methods and experiments were conducted at various points in the analytical scheme to determine the influence of sample collection, handling and analysis steps. Results were of aid in determining where emphasis should be placed to improve the end result.

223 Richardson, William L. 1976. AN EVALUATION OF THE TRANSPORT CHARACTERISTICS OF SAGINAW BAY USING A MATHEMATICAL MODEL OF CHLORIDE. In: Modeling Biochemical Processes in Aquatic Ecosystems (R.P. Canale, ed.). Ann Arbor Science Publishers, Inc., Ann Arbor MI. pp. 113-139.

A coarse-grid, mass balance model has been developed to deduce a circulation pattern by tracing chloride concentrations in Saginaw Bay. First, a steady-state or average annual circulation pattern previously calibrated with 1965 data is reviewed and the attempt to verify this pattern using 1974 data is presented. Finally, a time-dependent approach is presented which is used to calibrate seasonal circulation patterns for 1974.

The initial model was structured to determine the average chloride distribution in the bay. The steady state, finite difference equations for mass balance were developed by Thomann for his work on the Delaware Estuary in the early 1960's (Thomann 1963). Model parameters include chloride loads, segment volumes, lengths, and interfacial areas, and boundary conditions at Lake Huron. The model also requires an a priori specification of advective and dispersive transport. In the particular application of the model addressed herein the transport parameters become the unknowns and are calibrated so that the calculated chloride concentration in each model segment fits the measured.

This calibration was done on an annual average basis using data collected in 1965 (Richardson 1974). Advection from Lake Huron to the northwest outer segment of the bay was determined to be about 6370 m^3/sec. The dispersive transport was determined to be on the order of 5 km^2/day.

Using 1974 data, this calibrated average circulation scheme was verified as valid for most of the year, except for the spring.

Using a time-variable solution to the model equations it was determined that during the spring a 75% reduction of advective transport from outer to inner bay must be included, as well as a 50% reduction in dispersion, to obtain a reasonable fit to measure spring chloride levels.

This reduction in transport is indicated by the development of a thermal bar structure which can form a vertical barrier to mass exchange between the nearshore and the open lake. A reasonable fit of computed versus measured chloride concentrations was obtained for most segments throughout the year. The circulation scheme is considered to be calibrated and the necessary verification will be the subject of future research.

Source: LLRS

224 Richardson, William L. and Victor J. Bierman, Jr. 1976. A MATHEMATICAL MODEL OF POLLUTANT CAUSE AND EFFECT IN SAGINAW BAY, LAKE HURON. In: Water Quality Criteria Research of the U.S. Environmental Protection Agency. U.S. Environmental Protection Agency, Corvallis OR. Publication No. EPA-600/3-76-079. pp. 138-158.

This paper emphasizes methodology and practical considerations of applying an existing phytoplankton-chlorophyll model to Saginaw Bay. Conducted in support of the U.S.-Canadian Upper Lakes Reference Study, the preliminary results of this modeling effort reveal Saginaw Bay to be a unique system with large nutrient inputs and large material gradients. To get a reasonably close calibration of calculated material concentrations to observed data, the authors had to use nutrient recycling rates ten times those used for Lake Ontario. Carbon-chlorophyll and phosphorus-chlorophyll ratios were reduced along with saturated growth rates for phytoplankton. The results point out the need to modify structure to include more biological detail.

225 Richardson, W.L. and N.A. Thomas. 1976. A REVIEW OF EPA'S GREAT LAKES MODELING PROGRAM. Proc. Conf. on Environmental Modeling and Simulation, Cincinnati, Ohio, April 19-22, 1976. U.S. Environmental Protection Agency, Cincinnati OH. Publication No. EPA-600/9-76-016. pp. 20-25.

The Large Lakes Research Station at Grosse Ile, Michigan, is responsible for implementing the EPA Office of Research and Development's research program for the Great Lakes. The objective is to be able to describe the transport and fate of pollutants. Mathematical models provide the researcher with the necessary tools for accomplishing this task and, once calibrated and verified, they can be used by water quality managers confronted with making policy decisions. Several levels of modeling research have been initiated which address water quality issues ranging from lake-wide

to nearshore effects, and from eutrophication to hazardous materials. Concurrent surveillance and experimentation programs are being conducted for model calibration and verification. An overview of the EPA Great Lakes modeling program is presented including results from some specific models.

226 Thomas, Nelson A. 1976. ACCUMULATION AND TRANSPORT OF ENERGY-RELATED POLLUTANTS BY BENTHOS. Proc. Second Federal Conf. on the Great Lakes, Argonne, Illinois, March 25-27, 1975. pp. 361-368.

Benthos concentrate many heavy metals and organics in relation to the concentration in the surrounding water, accumulating much more from water than from sediments. The accumulation of pollutants is higher in benthos than in fish, but the benthos -- as a source of food for fish and other aquatic life -- apparently do not transfer significant amounts of pollutants. Often the benthic animals metabolize the pollutants to daughter products. The only important role benthos might have in the transport of pollutants is the resuspension of materials below the sediment surface, a possibility requiring further investigation.

1967

227 Brungs, William A. 1967. DISTRIBUTION OF COBALT 60, ZINC 65, STRONTIUM 83, AND CESIUM 137 IN A FRESHWATER POND. U.S. Public Health Service, Cincinnati OH. Publication No. 999-RH-24.

228 Jackson, Herbert W. and William A. Brungs. 1967. BIOMONITORING OF INDUSTRIAL EFFLUENTS. Proc. 21st Industrial Waste Conf. Purdue Univ. 50(1): 117-124.

229 Thatcher, Thomas O. 1967. ACUTE TOXICITY OF LAS TO VARIOUS FISH SPECIES. Proc. 21st Industrial Waste Conf. Purdue Univ. 50(2): 996-1002.

1969

230 Imlay, Marc J. 1969a. SOME RESEARCH NEEDS AND METHODS FOR PROTECTING NAIADS FROM EXTINCTION. American Malacological Union. Annual Report. pp. 49-51.

231 Imlay, Marc J. 1969b. A DUAL BEHAVIORAL INTERPRETATION OF A SINGLE ENVIRONMENTAL STIMULUS WITH FRESHWATER MUSSELS. American Malacological Union. Annual Report. pp. 21-22.

1970

232 Brungs, William A. 1970. EFFECTS OF HEATED WATER FROM NUCLEAR PLANTS ON AQUATIC LIFE. In: Nuclear Power and the Public. University of Minnesota Press, Minneapolis MN. pp. 52-59.

1971

233 Leonard, Edward N. 1971. THE DETERMINATION OF COPPER IN FISH TISSUES BY ATOMIC ABSORPTION SPECTROPHOTOMETRY. Atomic Absorption Newsletter 10: 84-85.

234 Lucas, Allen M. and Nelson A. Thomas. 1971. SEDIMENT OXYGEN DEMAND IN LAKE ERIE'S CENTRAL BASIN 1970. Proc. 14th Conf. Great Lakes Res. 1971: 781-787.

1972

235 Brungs, William A. 1972. EFFECTS OF PESTICIDES AND INDUSTRIAL WASTES ON SURFACE WATER USE. In: River Ecology and Man. Academic Press, New York NY. pp. 353-365.

236 Christensen, Glenn M. 1972. GRAVEL IN THE GEARS. Minnesota Volunteer 35: 62-65.

237 Imlay, Marc J. 1972. GREATER ADAPTABILITY OF FRESHWATER MUSSELS TO NATURAL THAN ARTIFICIAL DISPLACEMENT. In: Bulletin of the American Malacological Union. pp. 43-44.

238 Thomas, Nelson A. 1972. LAKE MICHIGAN ENTRAINMENT STUDIES -- BIG ROCK NUCLEAR POWER PLANT, SCANABA POWER PLANT, NOVEMBER-DECEMBER 1971. U.S. Environmental Protection Agency, Grosse Ile, MI. Working Report No. 1.

Source: LLRS

1973

239 Brungs, William A. 1973. CONTINUOUS-FLOW BIOASSAYS WITH AQUATIC ORGANISMS: PROCEDURES AND APPLICATIONS. In: Biological Methods for the Assessment of Water Quality. American Society for Testing and Materials, Philadelphia, PA. STP 528. pp. 117-126. (ERL-D Reprint #87)

Source: ERL-D

240 Eaton, John G. 1973. RECENT DEVELOPMENTS IN THE USE OF LABORATORY BIOASSAYS TO DETERMINE "SAFE" LEVELS OF TOXICANTS FOR FISH. In: Bioassay Techniques and Environmental Chemistry. Ann Arbor Science Publishers, Ann Arbor MI. pp. 107-115.

241 Hokanson, Kenneth E.F. and Charles F. Kleiner. 1973. EFFECTS OF CONSTANT AND RISING TEMPERATURES ON SURVIVAL AND DEVELOPMENTAL RATES OF EMBRYONIC AND LARVAL YELLOW PERCH, PERCA FLAVESCENS (MITCHELL). In: Early Life History of Fish. Proceedings of an International Symposium Held at the Dunstaffnage Marine Research Laboratory, Scottish Marine Biological Association, Oban, Scotland, May 17-23, 1973. pp. 473-448. (ERL-D Reprint #111)

Source: ERL-D

242 Siefert, Richard E. and William A. Spoor. 1973. EFFECTS OF REDUCED OXYGEN ON EMBRYOS AND LARVAE OF THE WHITE SUCKER, COHO SALMON, BROOK TROUT, AND WALLEYE. In: Early Life History of Fish. Proceedings of an International Symposium Held at the Dunstaffnage Marine Research Laboratory, Scottish Marine Biological Association, Oban, Scotland, May 17-23, 1973. pp. 487-495. (ERL-D Reprint #110)

Source: ERL-D

243 Stephan, Charles E. and Donald I. Mount. 1973. USE OF TOXICITY TESTS WITH FISH IN WATER POLLUTION CONTROL. In: Biological Methods for the Assessment of Water Quality. American Society for Testing and Materials, Philadelphia, PA. STP 528. pp. 164-177. (ERL-D Reprint #88)

Source: ERL-D

244 Thomas, N.A. 1973. ASSESSMENT OF FISH FLESH TAINTING SUBSTANCES. In: Biological Assessment of Water Quality. American Society for Testing and Materials, Philadelphia, PA. STP 528. pp. 178-193.

245 Thomas, Nelson A. and Katherine W. Hartwell. 1973. ZOOPLANKTON ENTRAINMENT AT THE MONROE POWER PLANT -- MONROE, MICHIGAN 1973. U.S. Environmental Protection Agency, Grosse Ile, MI. Working Report No. 2. 25 p.

Source: LLRS

1974

246 Richardson, William L. 1974. MODELING CHLORIDE DISTRIBUTION IN SAGINAW BAY. Proc. 17th Conf. Great Lakes Res. 1974: 462-470.

247 Robertson, Andrew, Floyd C. Elder, and Tudor T. Davies. 1974. IFYGL CHEMICAL INTERCOMPARISONS (IFYGL). Proc. 17th Conf. Great Lakes Res. 1974: 682-696.

1975

248 Bierman, V.J., Jr., W.L. Richardson, and D.M. Dolan. 1975. RESPONSES OF PHYTOPLANKTON BIOMASS IN SAGINAW BAY TO CHANGES IN NUTRIENT LOADINGS. A Report to the International Reference Group on Upper Lakes Pollution. International Joint Commission, Windsor, Ontario.

249 Rogers, R.H., N.J. Shah, J.B. McKeon, C. Hilson, L. Reed, V. Elliott Smith, and Nelson A. Thomas. 1975. APPLICATION OF LANDSAT TO THE SURVEILLANCE AND CONTROL OF EUTROPHICATION IN SAGINAW BAY. Proc. Tenth International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, October 6-10, 1975. 11 p.

250 Stroud, Richard K., Gerald R. Bouck, and Alan V. Nebeker. 1975. PATHOLOGY OF ACUTE AND CHRONIC EXPOSURE OF SALMONID FISHES TO SUPERSATURATED WATER. In: Chemistry and Physics of Aqueous Gas Solutions. The Electrochemical Society, Inc. Also: Tech. Paper No. 3757. Agric. Expt. Sta., Oregon State Univ., Corvallis OR. (ERL-D Reprint #132)

Source: ERL-D

251 Thomas, Nelson A., Katherine Hartwell, and William E. Miller. 1975. GREAT LAKES NUTRIENT ASSESSMENT. Proceedings: Biostimulation-Nutrient Assessment Workshop, Corvallis, Oregon, October 16-17, 1973. U.S. Environmental Protection Agency, Corvallis, Oregon. Publication No. EPA-660/3-75-034. pp. 226-243.

Source: LLRS

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